Phase-Differentiated Black Hole Cosmology: A Framework for Nested Universes, Variable Constants, and CPT-Generalized Horizon Transitions

Franz Kruhm
Independent Research

Abstract

We propose a cosmological framework in which black hole horizons function as phase-transition boundaries between causally isolated universes. Extending CPT-symmetric cosmology (Boyle, Finn & Turok 2018) and Cosmological Natural Selection (Smolin 1992), we argue that the phase relationship imposed at a horizon need not be a strict CPT reversal, but may vary continuously as a function of black hole parameters — mass, spin, and charge. This generalization implies that child universes inherit not fixed physical constants but phase-dependent constants, with no privileged scale. The observable universe is reframed as the interior of a black hole whose horizon imposed a specific phase shift on a parent-universe vacuum, explaining the apparent fine-tuning of constants as a geometric inheritance rather than anthropic selection. We further propose that Hawking radiation encodes the CPT-conjugate signature of infalling matter, constituting the 'exit' demanded by phase-reversal symmetry, and that this resolves the information paradox within the phase-shift framework.

1. Introduction

The standard cosmological model offers no account of why the fundamental constants — the fine structure constant, the speed of light, the cosmological constant — take the values they do. Anthropic selection arguments, while logically consistent, are explanatorily unsatisfying. Smolin's Cosmological Natural Selection (CNS) proposed that black hole formation events seed child universes with slightly mutated constants, yielding a Darwinian landscape of cosmologies. Separately, Boyle, Finn and Turok proposed that the Big Bang produced two universes related by CPT symmetry — a matter universe running forward in time, and its conjugate running backward, together forming a globally CPT-symmetric system invisible to each other by construction.

The framework presented here synthesises and extends both proposals. We argue that: (1) black hole horizons are phase boundaries between universes; (2) the phase relationship at each horizon is not restricted to CPT reversal but is a continuous function of horizon geometry; (3) physical constants are not inherited with mutation, but are determined by the phase shift itself; and (4) there is no privileged scale — the nesting of universes within black holes within

universes is self-similar and unbounded in both directions.

2. The Horizon as Phase Boundary

General relativity's maximally extended Schwarzschild solution (Kruskal-Szekeres coordinates) already contains four spacetime regions: two exterior regions, a black hole interior, and a white hole interior. The white hole — thermodynamically disfavoured in our universe — is precisely what phase-reversal symmetry demands: if matter transits inward at a black hole, its conjugate must transit outward somewhere. The resolution to the apparent absence of white holes is that they exist, but are phase-shifted out of observational reach.

We define a generalised phase operator Φ acting on quantum fields at the horizon. In the Boyle-Turok model, $\Phi = CPT$. We propose instead:

$$\Phi(M, J, Q) = C^{\alpha} P^{\beta} T^{\gamma}$$

where M, J, Q are black hole mass, angular momentum, and charge respectively, and α, β, γ are continuous parameters determined by horizon geometry. Pure CPT reversal is recovered as a special case. A Kerr black hole ($J \neq 0$) has a ring singularity and an extended Penrose diagram with additional interior regions — geometrically distinct from the Schwarzschild case — suggesting a genuinely different phase relationship at its horizon.

3. Variable Constants as Phase Inheritance

If physical constants in a child universe are determined by Φ, and Φ varies with black hole parameters, then different black holes produce child universes with different constants. Critically, this includes the speed of light c, which we treat not as a universal invariant but as a phase-dependent parameter of each universe's local vacuum structure. Scale itself — the relationship between length, time, and energy — is set by the phase shift at the originating horizon.

This implies no privileged scale exists across the full ensemble. What we call 'the speed of light' is the locally stable vacuum parameter of our particular phase-shifted universe. Observers in a child universe of different phase would measure a self-consistent c', with no experiment available to either observer to detect the discrepancy — they are causally isolated by construction.

This resolves the fine-tuning problem without anthropic selection: our constants are what they are because our universe was born from a black hole that imposed a specific Φ. The question 'why these constants?' becomes 'what were the parameters of our parent black hole?' — a question in principle answerable if a mapping between Φ and constants can be derived.

4. Hawking Radiation as the Phase-Conjugate Exit

A phase-reversal model demands that if matter enters at the black hole horizon, its phase conjugate must exit. The apparent violation of this — the absence of observable white holes — is resolved by noting that Hawking radiation already satisfies this requirement. In the standard derivation, virtual particle pairs near the horizon result in one particle escaping and the other falling inward. The escaping particle is, in a precise quantum field theoretic sense, the CPT conjugate of the infalling partner.

Under the generalised phase operator $\Phi(M, J, Q)$, Hawking radiation is the phase-conjugate emission corresponding to whatever phase shift the specific horizon imposes. This reframes the information paradox: information is not lost, it is phase-shifted. The outgoing radiation encodes the complete state of infalling matter in the conjugate phase, which is precisely why it appears thermal and information-free to observers in the original phase — they lack the conjugate detector required to decode it.

5. Self-Similar Nesting and the Absence of Privileged Scale

The framework is self-similar by construction. Our observable universe is the interior of a black hole in a parent universe. The black holes our universe contains are the birth events of child universes. There is no ground level — no smallest or largest universe — and no privileged scale at which the nesting terminates. This is consistent with scale relativity (Nottale 1993), which holds that the laws of physics should be independent of the scale at which they are expressed.

Each level of nesting is causally isolated from adjacent levels. Parent universes cannot observe child universes (information cannot exit the child's horizon into the parent). Child universes cannot observe parent universes (the parent's structure is encoded only in the phase shift that set the child's constants at birth). The ensemble is therefore consistent with all current observational constraints while being, in principle, empirically distinguishable from alternatives if a mapping between Φ and constants is established.

6. Discussion and Predictions

The phase-shift framework makes several predictions distinguishable from both standard CNS and pure CPT cosmology:

6.1 Black hole parameters should correlate with child universe constants in a structured, non-random way. If a mapping $\Phi(M,J,Q) \rightarrow \{c, \blacksquare, G, \alpha...\}$ can be derived from first principles, it would constitute a predictive theory of constants.

6.2 Hawking radiation from black holes of different spin should differ in subtle quantum correlations beyond the thermal spectrum — a signature of the different phase operators at Kerr versus Schwarzschild horizons.

6.3 The Big Bang should exhibit CPT-like symmetry in its initial conditions — consistent with the Boyle-Turok prediction — but with the specific CPT parameters determined by parent black

hole geometry rather than being exact CPT reversal.

7. Conclusion

We have outlined a framework in which black hole horizons are generalised phase boundaries, the physical constants of each universe are determined by the phase shift imposed at its birth horizon, Hawking radiation constitutes the required phase-conjugate exit demanded by symmetry, and the structure of reality is self-similar across scales with no privileged level. The framework synthesises and extends CPT-symmetric cosmology and Cosmological Natural Selection, resolving the fine-tuning problem through geometric inheritance rather than selection, and reframes the black hole information paradox as a phase-encoding problem rather than information destruction.

The central open question is the derivation of the explicit mapping $\Phi(M,J,Q) \rightarrow$ physical constants. This constitutes the primary theoretical programme implied by the framework.

References

[1] Boyle, L., Finn, K., & Turok, N. (2018). CPT-Symmetric Universe. *Physical Review Letters*, 121, 251301.

[2] Smolin, L. (1992). Did the Universe Evolve? *Classical and Quantum Gravity*, 9, 173–191.

[3] Nottale, L. (1993). *Fractal Space-Time and Microphysics*. World Scientific.

[4] Magueijo, J. (2003). New varying speed of light theories. *Reports on Progress in Physics*, 66, 2025.

[5] Hawking, S.W. (1975). Particle Creation by Black Holes. *Communications in Mathematical Physics*, 43, 199–220.

[6] Maldacena, J. & Susskind, L. (2013). Cool horizons for entangled black holes. *Fortschritte der Physik*, 61, 781–811.

[7] Penrose, R. (1965). Gravitational Collapse and Space-Time Singularities. *Physical Review Letters*, 14, 57.